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(54) Centrifugal separator

(57) A centrifugal separator for separating contaminants from contaminated fluids comprising a casing (1) defining a chamber within which a hollow rotor (10) is rotatably carried by bearing means (8,9). Contaminated fluid is received within the rotor from an inlet passage (4, 11, 20) passing through said bearing means. The rotor is rotated, to effect centrifugal separation of the contaminants from the fluid by fluid discharging from the interior of the motor through reaction nozzles (14) into the casing chamber which is provided with a fluid outlet (2).

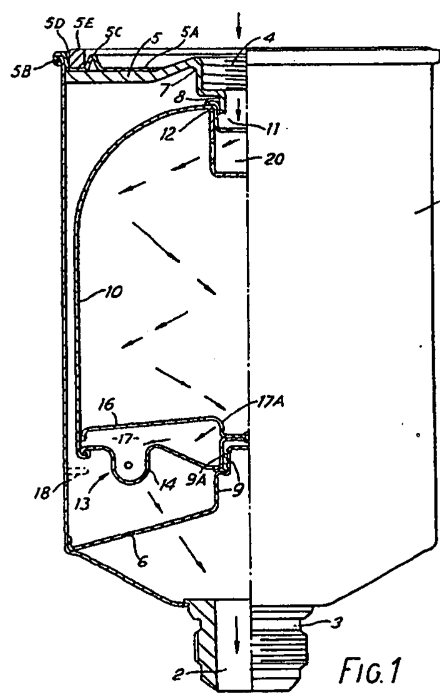

FIG. 1

The drawings riginally filed were informal and the print here reproduced is taken from a later filed formal copy.

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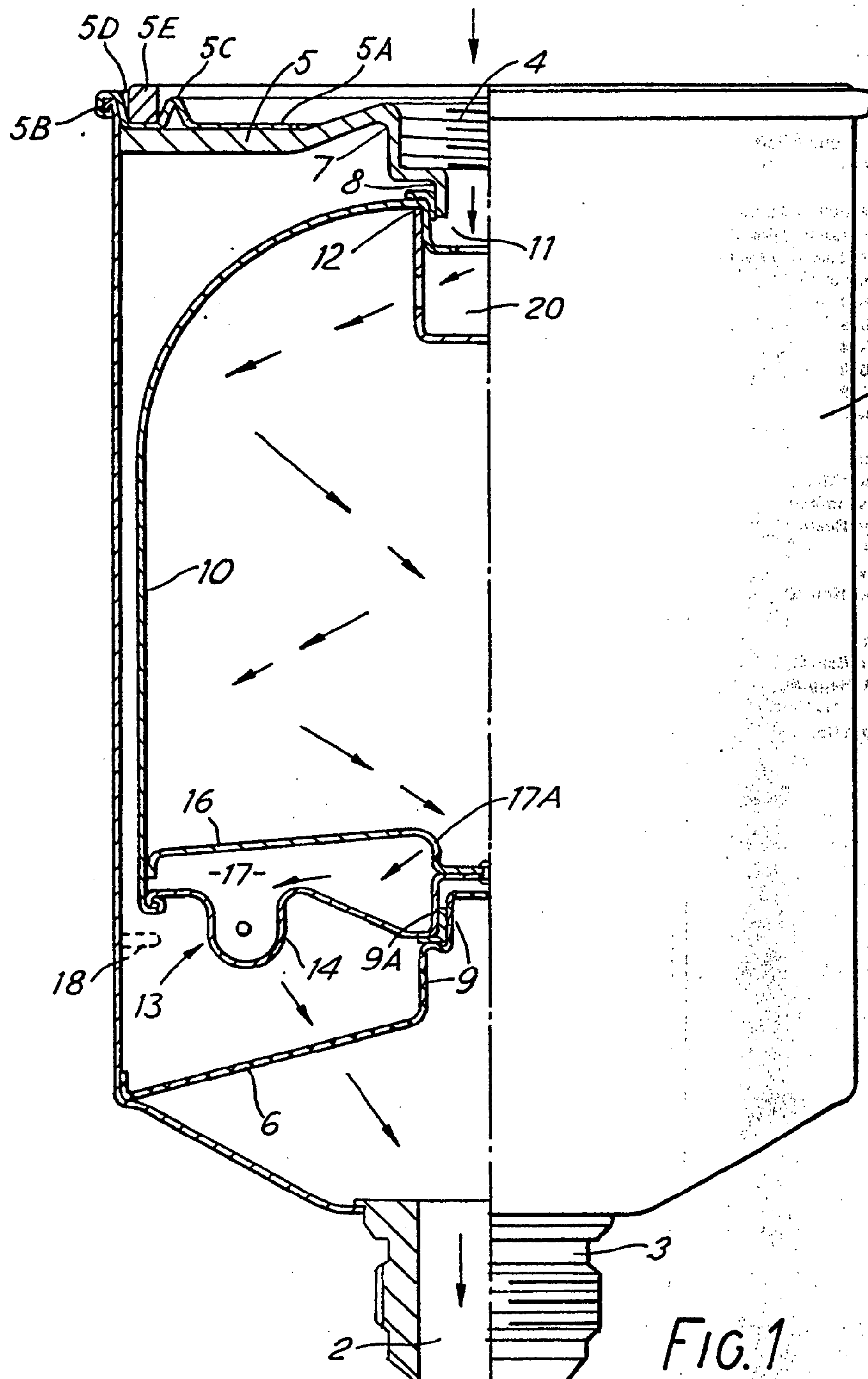

FIG. 1

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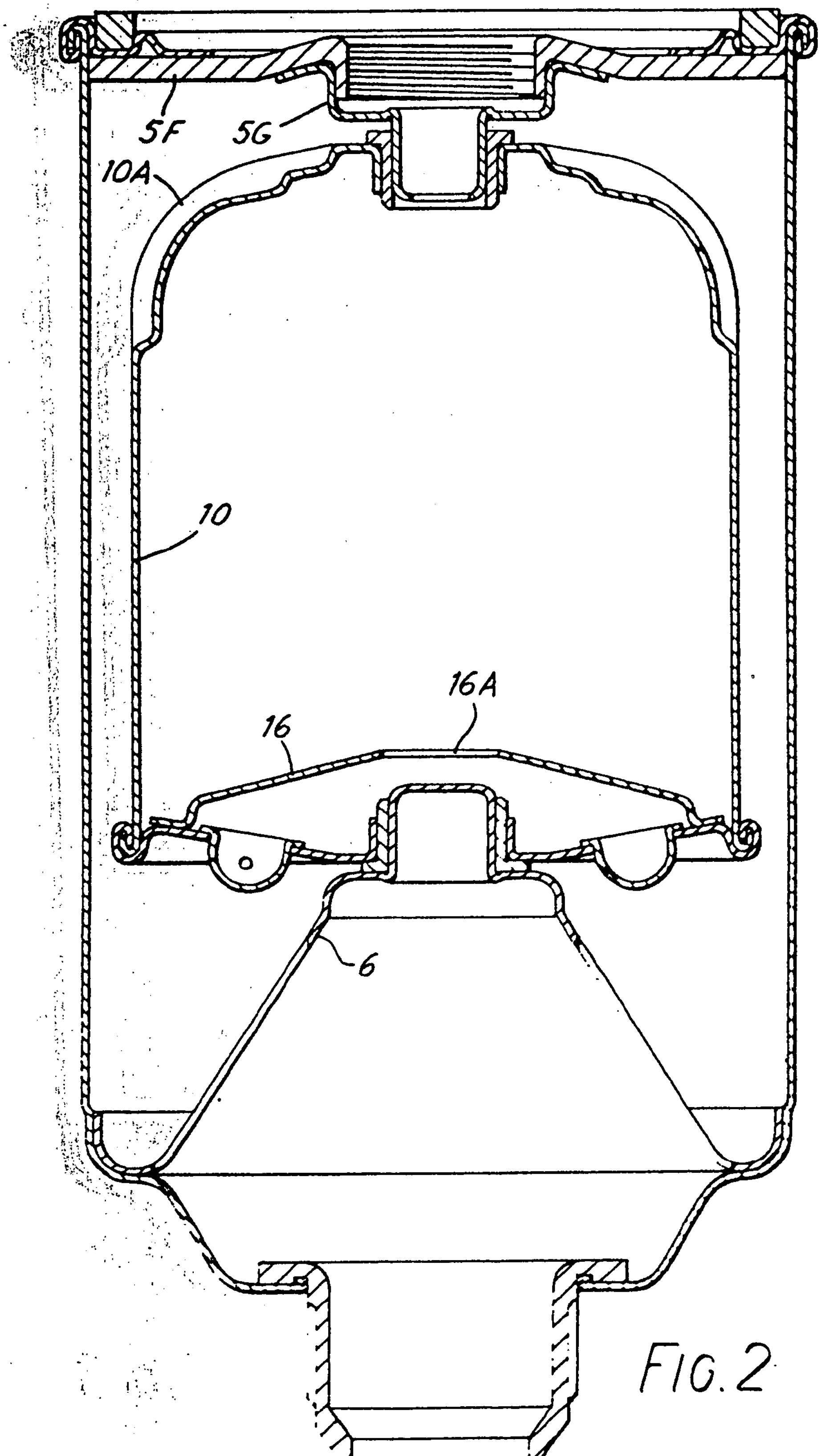

FIG. 2

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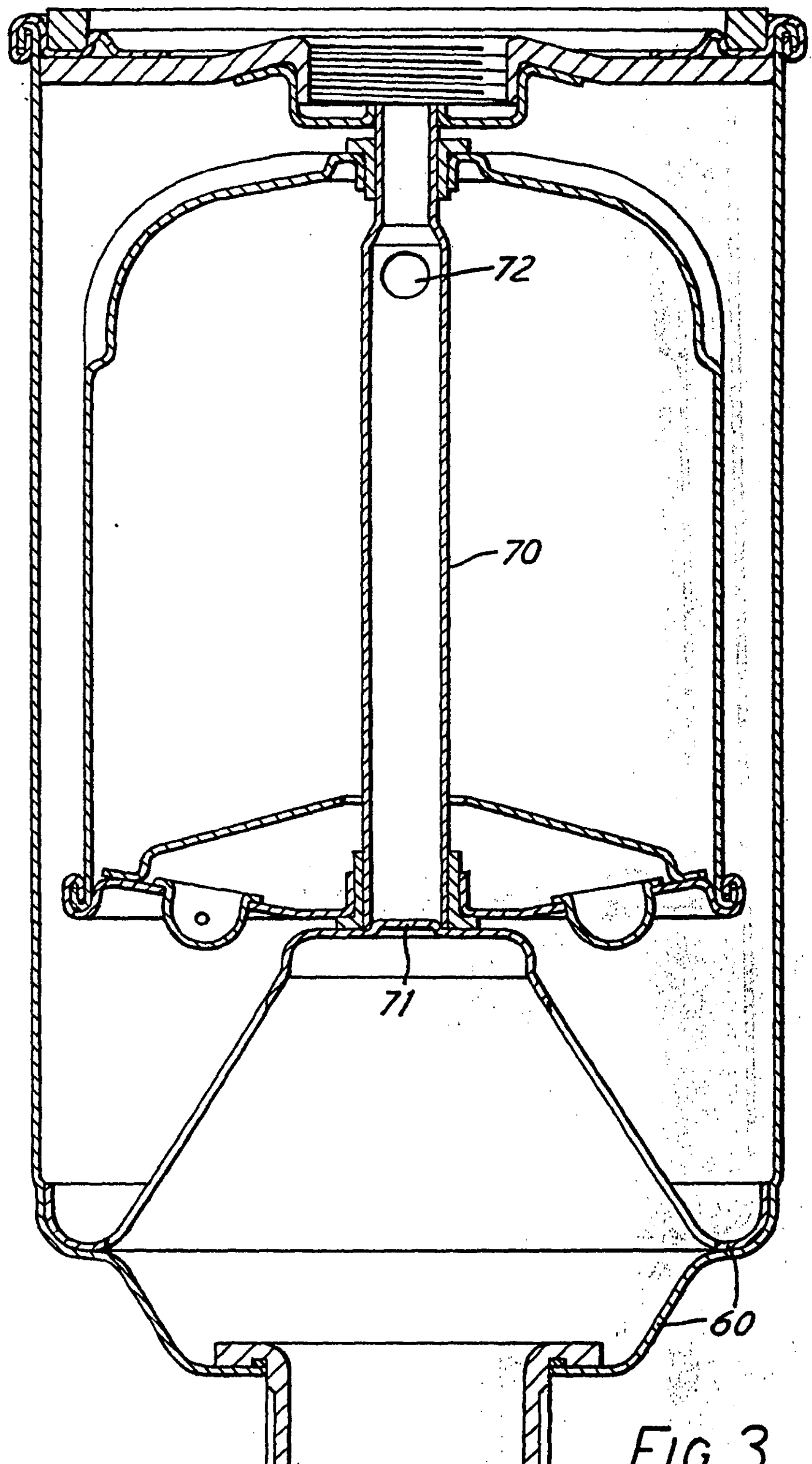

FIG. 3

SPECIFICATION

Centrifugal separator

This invention relates to centrigal separators for separating contaminants from contaminated fluids, and particularly for extracting solid matter from oil or other fluids or for separating a heavier fluid from a lighter fluid (for example, water from fuel oil). Such separators include a rotatable drum through which fluid is fed so that during the period when a part of the fluid remains in the drum it is subjected to centrifugal action caused by the rotation. This causes solid matter in the fluid or the heavier of the two fluids to be separated and be retained around the circumferential wall of the drum while the "cleaned" fluid is taken to where it is required for use. The drum is provided with one or more outlet nozzles through which fluid leaves the interior of the drum, the fluid issuing from the nozzle with a substantially tangential component with respect to the drum whereby the drum is caused to rotate by the reaction of the jets of fluid issuing from the nozzles. Subseqently such a centrifugal separator will be referred to as of the kind described.

The invention is particularly concerned to make improvements in centrifugal separators of the kind described such that the separator is a low cost product which may be disposed of in its entirety and replaced with a new unit. Conventional centrifugal separators of the kind referred to must be dismantled for cleaning out the drum when it is approaching full and this is not only tedious and dirty but involves a relatively expensive construction of drum capable of being repeatedly readily opened up for cleaning and readily reassembled with tightly sealed joints.

Conventional fluid filters, such as oil filters, generally with paper elements, are basically mechanical strainers which include a filter element having pores which trap and segregate dirt from the fluid. Since the flow through the filter is a function of the pore size, filter flow will decrease as the filter pack becomes clogged with dirt. Since the filtration system must remove dirt at the same rate at which the dirt enters the oil a clogged conventional paper element filter cannot process enough oil to keep the dirt level of the oil at a satisfactory level. A further disadvantage of some mechanical strainer type filters is that they tend to remove oil additives. Furthermore, the additives may be depleted to some extent by acting upon trapped dirt in the filter instead of on a working surface of an engine as intended.

Centrifugal filters have previously been proposed which do not act as mechanical strainers but rather remove contaminants from the fluid by centrifuging, s overcoming these disadvantages. For example, such a filter is shown in GB Patent No. 1 089 355 in the name of The Glacier Metal Company Limited. In this filter there is a hollow rotor which is rotatably mounted on a spindle. The spindle which extends through the rotor has axial passageways which conduct oil into the interior of the rotor. In Figure 2, of the patent, a heavy cast base is shown with a close fitting outer casing spigotted on. In addition th rotor is a casting of considerable complication.

While centrifugal filters have an undoubtably superior performance to element type filters the need to be cleaned out has up till now necessitated a complicated construction with relatively heavy machined castings so that it will stand up to periodic cleaning to remove the sludge built up. This has probably militated against the more univeral use of centrifugal filters in engines. It has also not been possible to provide a warning system to show that the rotor bowl is full which further complicates the problem of maintenance.

The invention in its preferred forms provides a centrifugal filter which is wholly disposable after the vehicle has done a certain mileage and which is very similar as regards external appearance and fitting and size to a conventional automative spin-on engine block canister filter. To be wholly disposable the filter should be of simple and low cost constrution avoiding expensive machined parts and the total number of parts should be kept to a minimum. It should also be resistant to "opening up" to prevent unauthorised attempts to clean out or reclaim the filter.

Accordingly the present invention in one aspect provides a centrifugal separator of the kind described which comprises an outer housing, and a drum mounted to rotate within the housing about two separate stub axles. Generally the stub axles will extend between the inner and oute canisters. Also, the stub axles will normally be non-rotating; however, if desired they could be carried by and rotate with the drum.

According to a further aspect of the present invention a wholly disposable centrifugal separator of the kind described comprises an outer sheet metal canister having spaced therefrom an inner sheet metal canister, the inner and outer canisters both having at one end an opening, the edges of which are shaped to form in combination a bearing and journal for relative rotation of the canisters.

More particularly (though not exclusively) the invention provides a wholly disposable centrifugal separator of the kind described having an open ended rotor canister, a plate closing the open end hhaving tangential nozzles formed therein and a further plate attached to the internal periphery of the rotor canister and spaced from the nozzle plate thereby forming a second chamber in communication with the main rotor chamber, the rotor canister being mounted within a second canister with two separate stub axles extending between the outer canister and the rotor canister at each end thereof.

The stub axle assembly remote from the nozzl s may for exampl be formed by pr ssing out a lipped aperture in the end of the second canister remote from the nozzles to form a stub axle construction cooperating with a lipped aperture pressed out from the adjacent end of the first canister.

In one particular embodiment of the invention a lower stub axle assembly at the ends of the canisters close to th nozzles may be formed by pressing out an aperture in the nozzle plate to cooperate with a rotor support ring attached to the internal surface of the second canister.

Alternatively, in another embodiment, apertures formed in the first and second canisters at both the upper and lower ends may be joined by a simple stub axle.

Thus according to yet another embodiment of the invention in a centrifugal filter of the kind referred to, the journals stub axles or spigots for rotation of the rotor remain attached to the engine when the filter is removed. Thus the journal may be of more durable and expensive design as the expense of disposal is avoided.

The support ring referred to above, in addition to supporting and providing a bearing for the rotor, may also provide a baffle for oil leaving the nozzles and proceeding out of the second canister whereby the rotor canister may reach as high a speed as possible without drag caused by oil entering the annular space between the rotor canister and second canister.

Further aspects of the invention are hereinafter defined in the claims. In particular, it has been found to be sufficient to feed oil into the upper end of the inner canister, from an inlet at the upper end of the outer canister, without elaborate axial distribution systems which have been conventional in centrifugal oil separators. Also, to prevent oil passing upwardly between the inner and outer canister walls and thus inhibiting rotation of the inner canister, it has been found to be desirable to provide a deep sump below the inner canister. The size of this sump may be defined in a number of ways; for example, it is desirably at least 40 mm deep. It is also desirable that the inner canister has a volume no greater than two thirds that of the outer canister. Alternatively, it could be said that the radial spacing (x) between the canister walls and the height (y) of the sump are defined by the formula.

$$Y \geq \frac{1}{4}x$$

Embodiments of the invention will now be described by way of example wih reference to the accompanying diagrammatic drawings in which:

Figure 1 is a part-sectioned elevation of one form of centrifugal separator according to the invention which is intended for use as an oil cleaner for a motor vehicle;

Figure 2 is a vertical section through another form of a centrifugal separator according to the invention; and

Figure 3 is a vertical section through a third form of a centrifugal separator according to the invention.

Figure 1 shows a particular stub axle construction in which sheet metal lips on a canister forming the rotor cooperate with lips on a canister forming the shroud means.

Referring now in more detail to Figure 1 there is shown a pressed out sheet metal outer canister 1 having a union 3 providing an oil outlet 2 from which oil is led away from the separator to the engine via a flexible oil return pipe (not shown). The outer canister 1 comprises four simple sheet metal pr ss-ings, viz th body of canist r 1, the top closure 5, the top closure support ring 5A and a rotor support cage 6, all being joined together e.g. by the sheet metal rolled-over-joint technique or by simple welding. As shown, the top closure support ring 5A is connected to the body of the canister 5 by a rolled-over-joint 5B and has an annular upward projection 5C providing an annular groove 5D housing an annular resilient seal 5E. The top closure 5 has a screw-threaded opening 7 with a downturned extended lip 8, the opening 7 providing an oil inlet union 4 so that the whole centrifugal separator unit screws onto a boss on the engine in the same way as the spin-on element filter conventionally used. The rotor support cage or spider 6 attached to the inner surface of the canister 1 is provided with an upturned lip 9. The lips 8 and 9 thus form stub axles for the rotor.

The rotor 10 is a simple pressed-out canister having an aperture 11 to communicate with the oil inlet and also having a lip 12 which cooperates with the lip 8 to form a rotary bearing and a thrust bearing. Since lubrication is available from the oil and rotor canister may normally run around (or inside) the lip 8 with steel-to-steel contact without the necessity of providing a separate bearing. However, an L-section ring of low-friction bearing material may be provided as shown. The adequacy of the bearing arrangement will to a large extent depend on the number of revolutions the rotor is required to undertake before the rotor becomes full of dirt. Similarly, the lower end of the rotor canister is provided by a pressed out plate 13 which includes two pressed out nozzle outlets 14 and 15 (only one of which is shown). The lip 9 on the support spider 6 forms a bearing surface to run against an upturned rim 9A in the plate 13. Finally a further plate 16 spaced apart from the nozzle plate 13 provides a chamber 17 into which oil passes before entering the driving nozzles 14 and 15 to drive the rotor. This oil leaves the separator via the outlet 2 after passing through the rotor support cage (i.e. spider 6).

Since the rotor canister 10 is required to rotate at its maximum speed for effective separation and needs to occupy the outer canister volume as fully as possible there is a tendency for oil leaving the rotor canister 10 to be driven up and relatively narrow clearance between the concentric walls of the rotor canister 10 and the outer canister 1. The rotor support cage or spider 6, if suitably apertured or shaped, may constrain oil proceeding in this direction while not at the same time providing a restriction to free downward flow of oil. A small lip 18 may also prove effective in this respect. An oil inlet directing chamber 20 also of pressed-out sheet metal construction may be pressed over or otherwise fixed to lip 12 over the upper aperture 11 in the rotor 10, so that the oil will enter through the outer canister 1 as shown by the arrows and then be directed through a series of radial apertures in the wall of the chamber 20 towards the outside of the rotor 10. The arrows show how the oil is first directed towards the outer wall of the rotor 10 and is prevented from passing directly into the nozzle chamber 17 by the formed nozzle plate 16 before experiencing the necessary dwell time in the rotor so that efficient dirt separation can take place. It will also be noted that the oil, before entering the nozzle chamber 17, has to migrate t wards the axis of

rotation before turning into the nozzle chamber 17 via holes 17A as shown by the arrow.

It is to be noted that here there is no spindle extending through the rotor; such a spindle is present in all conventional centrifugal separators of the kind described and directs the oil flow into the rotor. It has now been found that sufficient dwell time can surprisingly be obtained without the need for a spindle extending through the rotor. It is sufficient for the oil to turn towards the outer wall of the rotor at the inlet and to turn away from the wall before it enters the nozzle chamber. The omission of a through spindle drastically reduces the cost of the assembly and eases "permanent" joining of the rotor canister and outer canister so that it cannot be tampered with and leaves more space for oil in the rotor.

Figure 2 is similar to Figure 1 and only differences will be described. These are as follows:-

1. The oil inlet chamber 20 is omitted; as mentioned previously in its optional in all embodiments of the invention.

2. The top closure 5 is made in two parts 5F and 5G.

3. The rotor canister 10 has strengthening ribs 10A at the top corner.

4. The plate 16 is simplified and has an axial opening 16A.

5. Lastly, and most importantly, the spider 6 is axially lengthened to provide a deep sump at the lower end of canister 1.

Figure 3 differs from Figure 2 in that lip 8 is extended to form a full length hollow spindle 70 fitting over a slight projection 71 on spider 6. Oil enters the inner canister 10 through one or more lateral openings 72 in the spindle 70. Although a continuous spindle adds to costs it obviates any problems which might arise due to misalignment of the stub axles.

In all embodiments of the invention, it may be desirable to provide a pressure relief valve in the upper part of the outer canister to release excess air pressure to atmosphere.

The following modifications of the Figure 1 embodiment may also be advantageous:

(a) the provision of a horizontal annular oil deflector plate extending outwards from the base of chamber 20 e.g. to approximately half te radius of the rotor.

(b) the provision of a solid spigot or stub shaft at the lower bearing point.

(c) heat-hardening of bearing surfaces provided by pressed metal.

Desirably the spinning rotor should be in vertical equilibrium so that there is little or no resultant force acting on the upper or lower thrust bearings. In the Figure 1 embodiment this may be aided by providing a bleed opening in the centre of the lower rotor wall to connect the main rotor chamber with the space above the lower stub axle or spigot. Such a bleed arrangem nt, beside effecting som m asur of pressure balancing, will also facilitate lubrication of the lower bearing.

It will be noted that in all the embodiments of the invention the bearings provided by the outer canister are rigid and not spring loaded.

The deep sump arrangements shown in Figures 2 and 3 have the advantage that any oil build up is unlikely to get near the nozzles or the periphery of the rotor. Arrangements with gauzes have been proposed to solve this problem but they impeded oil flow.

In practice oil enters the filter at a pressure of between 60 and 100 lbs. per sq. in. and has a rate of about 150 gals. per hour, and 150 gals. has got to leave per hr. at zero pressure in order not to have a build up. The zero pressure means that the outlet opening has to be about 8-12 times bigger than the inlet opening. Thus, typically there is an inlet of 1/8" diameter and an outlet hole of 1-1½" diameter.

CLAIMS

1. A centrifugal separator for separating contaminants from contaminated fluids comprising shroud means defining a first chamber, bearing means within the shroud means, a hollow rotor rotatably carried by the bearing means, said hollow rotor defining a second chamber for receiving contaminated fluid directly from an inlet passage passing through said bearing means, and connecting an inlet port at the upper end of the shroud means with the upper end of said second chamber, means to rotate said rotor and thereby cause contaminants in the contaminated fluid within said second chamber to migrate towards a side wall of said second chamber under the influence of centrifugal force and to be separated from such contaminated fluid, said means to rotate said rotor comprising outlet reaction port means in said rotor in fluid communication with said second chamber to cause said rotor to rotate upon discharge of fluid from said second chamber to said first chamber and outlet port means for discharging fluid from the bottom of said first chamber.

2. A centrifugal separator according to claim 1, wherein the relationship between the radial distanc (X) between the rotor and the shroud and the height (Y) of the first chamber below the rotor is substantially according to the formula

$$Y \geqslant \frac{1}{4} X$$

3. A centrifugal separator according to claim 1 or 2, wherein the bearing means comprises two separate axially aligned stub axles.

4. A centrifugal separator according to claim 3, wherein the stub axles are fixedly mounted at the respective ends of the shroud means.

5. A centrifugal separator according to claim 4, wherein the rotor has annular recesses at its respective ends, said recesses being journalled on said stub axles.

6. A centrifugal separator according to claim 5, wher in th rotor is of sheet metal.

7. A c ntrifugal separator according to any one of claims 3 to 6, wherein the stub axles are of sheet metal.

8. A centrifugal separator according to claim 7 wherein the bearings are formed by direct sheet

metal to sheet metal engagement.

9. A centrifugal separator according to claim 1, 2 or 3 wherein the bearing means comprises a spindle extending longitudinally of the first chamber and providing said passage.

10. A centrifugal separator according to claim 9 wherein the rotor is of sheet metal.

11. A centrifugal separator according to any preceding claim, wherein the rotor comprises an open-ended member, a first plate closing said open ended member, said outlet reaction port means comprising tangential nozzles formed in said plate, and a second plate spaced from first plate within said second chamber and dividing said second chamber into a nozzle chamber and centrifuging chamber, said nozzle chamber and said centrifuging chamber being in communication adjacent the rotary axis of the rotor.

12. A centrifugal separator for separating contaminants from contaminated fluids comprising shroud means defining a first chamber, bearing means within the shroud means, said bearing means including axially aligned stub axles, a hollow rotor rotatably carried by the bearing means, said hollow rotor defining a second chamber for receiving contaminated fluid from an inlet passage passing through said bearing means, means to rotate said rotor and thereby cause contaminants in the contaminated fluid within said second chamber to migrate towards a sidewall of said second chamber under the influence of centrifugal force and to be separated from such contaminated fluid, said means to rotate said rotor comprising outlet reaction port means on said rotor in fluid communication with said second chamber to cause said rotor to rotate upon discharge of fluid from said second chamber to said first chamber and outlet port means for discharging fluid from said first chamber.

13. A centrifugal separator for separating contaminants from contaminated fluids comprising shroud means defining a first chamber, bearing means within the shroud means, a hollow rotor rotatably carried by the bearing means, said hollow rotor defining a second chamber for receiving contaminated fluid from an inlet passage passing through said bearing means, means to rotate said rotor and thereby cause contaminants in the contamiated fluid within said second chamber to migrate towards a sidewall of said second chamber under the influence of centrifugal force and to be separated from such contaminated fluid, said means to rotate said rotor comprising outlet reaction port means in said rotor in fluid communication with said second chamber to cause said rotor to rotate upon discharge of fluid from said second chamber to said first chamber and outlet port means for discharging fluid from the bottom of said first chamber, said outlet port means being disposed on the rotational axis of the rotor at the opposite end of said first chamber to said inlet passage and being smaller in diameter than said first chamber so as to form an annular ledge at th bottom of the first chamber, the axial distance b tween the reaction p rts and the uppermost part of the ledg being at least 40 mm.

14. A centrifugal separator for separating contaminants from contaminated fluids comprising shroud means defining a first chamber, bearing means within the shroud means, a hollow rotor rotatably carried by the bearing means, said hollow rotor defining a second chamber for receiving contaminated fluid from an inlet passage passing through said bearing means, means to rotate said rotor and thereby cause contaminants in the contaminated fluid within said second chamber to migrate towards a sidewall of said second chamber under the influence of centrifugal force and to be separated from such contaminated fluid, said means to rotate said rotor comprising outlet reaction port means on said rotor in fluid communication with said second chamber to cause said rotor to rotat upon discharge of fluid from said second chamb r to said first chamber and outlet port means for discharging fluid from the bottom of said first chamber, said outlet port means being disposed on the rotational axis of the rotor at the opposite end of said first chamber to said inlet passage and being smaller in diameter than said first chamber so as to form an annular ledge at the bottom of the first chamber, th rection ports being spaced from the ledge such that the second chamber has a volume no greater than two thirds that of the first chamber.

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